MINOR STUDIES FROM THE PSYCHOLOGICAL LABORATORY OF CLARK UNIVERSITY.

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XII. ON NEARLY SIMULTANEOUS CLICKS AND FLASHES.

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Judgments of the time order of nearly simultaneous clicks and flashes have been studied by several investigators, but with discordant results. Exner[1] and Gonnesiat[2] find that the order click-flash can be recognized when the interval of time between the two stimuli is less than when the order is flash-click. Bloch,[3] Tracy[4] and Miss Hamlin,[5] on the contrary, find that the order flash-click is the more easily recognized.

In explanation of this difference Miss Hamlin suggests, on the basis of her own and Tracy's work, that it "depends on the fact that series of pairs of stimuli were used in one case [Exner's] and single pairs in the other. In his experiments on personal equation Gonnesiat finds rhythm a very important factor, and it may have been effective in these experiments of Exner's." The present study has chiefly in view a comparison of the 'series' and 'single pair' methods when judged by the same subjects.

Apparatus and Method. The apparatus consisted of an arrangement for producing the clicks and flashes, and of a double set of switches, one of which could be used to cut out single pairs of stimuli for observation, when single pairs were under investigation, while the other served to reverse the order from click-flash to flash-click without altering the other parts of the apparatus. The arrangement for producing the clicks and flashes consisted of a double revolving disk of special construction, so arranged as to make contact for an instant in two in-

[1] *Pflüger's Archiv*, XI, 1875, 403-432.
[2] *Récherches sur l'equation personnelle.* Paris, 1892, pp. 138-140.
[3] *Revue scientifique*, XXXIX, 585.
[4] *American Journal of Psychology*, V, 567 f.
[5] *Ibid.*, V, 564-575.

dependent electrical circuits.[1] One of the disks was fixed permanently upon the shaft of the instrument, and was divided into degrees; the other could be turned upon the shaft so as to alter the separation of the contact points (of which each disk carried one), and was provided with a vernier, by means of which the setting of the disks with relation to each other could be read to one-tenth of a degree. These disks were driven at the required speed by a small electric motor, the speed of the motor being properly reduced by the interposition of gears and pulleys. The actual clicks were given by a telephone, and the flashes by a Geissler tube and induction coil, both controlled by the instrument just described. The tube was encased in a blackened box, but seen directly through a horizontal slit 115 mm. long by 6 mm. wide. The room was partially darkened during experimentation.

It is hardly to be expected that an apparatus driven in such a manner by an electric motor should be wholly constant in rate. Careful timing showed a difference in rate of about 0.1 sec. per revolution,—from 899σ to 796σ,—during a five minutes' run of the apparatus. This, however, is less important in the present instance than the irregularity from revolution to revolution, which was such as to give a maximal mean variation of 10.9σ in an average of eight determinations taken at random from the records of a single minute. This variation is larger than could be wished, but as the contact points of the two disks were never more than 27° apart, it involves a variation of only 0.8σ in the time values of interest for this study. This variation makes the measurements rough, but leaves them of sufficient accuracy, it is believed, for the questions to be determined.

The time for any set of tests was found by calculation from the setting of the disks and the time for 100 revolutions of the disks taken with a stop-watch giving fifths of a second.

The rates at which the pairs of stimuli recurred when they were used in series were approximately: one-half, one, two, three and four seconds. Ten consecutive pairs were included in each series. When single pairs were used the intervals from test to test were taken at the operator's convenience.

The method of right and wrong cases was employed, the subjects being given an equal number of click-flash and flash-click orders irregularly mixed, and being required to register

[1] While the instrument was arranged for two independent circuits, it was found simpler in use to make the two circuits partially coincident, and by proper wiring to use only a single battery for producing both clicks and flashes.

an answer one way or the other each time, guessing, if in doubt.[1]

The number of trials given at each rate was never less than 100, and often more. The usual precautions against fatigue and expectant attention were taken, and to counteract the effects of practice, in part, each subject was given an hour's training before beginning serious testing. Part of the subjects, also, started at slow rates of speed, and part at fast. Of the subjects, C., P. and S. were accustomed to laboratory tests, the others not. S. had served also as subject for Miss Hamlin. The results of the tests are given in Table I, according to the subject, and in Table II in briefer form, according to the various rates of speed. In the first Table "kind" indicates whether a single pair or a series of pairs of stimuli was used. The second column gives the interval in seconds at which the pairs of stimuli recurred when the series method was used. In counting the tests each order presented was counted as one; thus 200 tests means 100 trials of the click-flash order and 100 of the flash-click order. "Time" is the interval separating the stimuli, given in thousandths of a second. The last two columns indicate the time necessary to give 75% of right answers, calculated according to Fullerton and Cattell's Table.[2]

In Table II, the results of these calculations have been collated to show at a glance the individual variations and the effects of the various rates of speed. The bracketed times represent the results of verification tests, being in each case a repetition at the close of the whole experiment of the particular form of test on which the subject began.

TABLE I.

Subject C.

Date.	Kind.	Interval in sec.	No.	Time.	% correct. C.	% correct. F.	Time necessary to give 75% rt. cases. C.	Time necessary to give 75% rt. cases. F.
Jan. 10.	Singles	—	200	74.1	67	83	114	53
" 12.	Series	3	150	15.6	70	93	20	7
" 17.	"	2	100	26.9	72	82	31	20
" 18.	"	1	100	40.0	66	78	66	35
" 24.	"	½	100	10.8	64	70	20	14
" 26.	Singles	—	200	67.5	63	62	138	150
						Av.,	61	45

[1] Further experiments, by the method of minimal changes, are now in progress. Since their completion has been unavoidably delayed, and since the series taken by the method of right and wrong cases are complete in themselves, it seems best to publish this study at the present time.

[2] Fullerton and Cattell: On the Perception of Small Differences, Univ. of Penna., 1892.

Subject P.

Jan. 10.	Series	1	200	42.5	78	100	37	—
" 11.	"	½	200	42.3	72	80	49	34
" 22.	"	2	100	20.5	88	88	12	12
" 25.	"	3	100	13.9	78	90	12	7
" 27.	"	4	100	10.7	84	68	7	16
" 29.	Singles	—	200	25.2	83	81	18	19
Feb. 3.	Series	1	100	19.1	68	82	28	14
						Av.,	23	17

Subject W.

Jan. 15.	Singles	—	200	69.4	60	89	183	38
" 25.	Series	4	100	10.6	94	96	5	4
" 27.	"	3	100	10.8	94	94	5	5
						Av.,	64	16

Subject Ck.

Jan. 14.	Singles	—	200	76.4	74	77	80	69
" 15.	Series	4	100	16.4	64	80	32	13
" 26.	"	3	100	16.6	88	96	10	6
" 27.	"	2	100	21.8	74	92	23	10
Feb. 3.	"	1	100	22.5	72	66	26	37
" 4.	"	½	100	41.6	66	66	68	68
" 14.	Singles	—	200	45.8	81	94	35	20
						Av.,	39	32

Subject Sm.

Jan. 14.	Series	1	150	38.7	78	86	34	24
" 15.	"	½	100	43.1	78	74	40	45
						Av.,	37	35

Subject S.

June 11.	Series	1	100	35.0	74	90	37	18
" 11.	Singles	—	100	53.3	84	86	36	33
" 13.	Series	2	100	22.2	78	96	20	9
" 14.	"	½	100	34.8	72	84	40	24
" 15.	Singles	—	100	50.9	80	84	41	35
						Av.,	35	24

An examination of these Tables will show that the results obtained, with few and unimportant exceptions, accord with those of Bloch, Tracy and Miss Hamlin, and are contrary to those of Exner and Gonnesiat; in other words, that the click-flash order requires a longer interval of time for recognition than the flash-click[1] order. In seeking for an explanation of her results, Miss

[1] The tendency to take the flash as coming earlier was noticed by some of the subjects themselves. Ck., for example, during one test said: "They all seem like flashes [first]. I have to work hard to make any clicks first." S. found it rare to get a click distinctly first, and hence answered "click first," for any cases where they appeared simultaneous or with the flash only slightly ahead. The flashes were commonly distinctly separate from the clicks when they actually came first.

Hamlin suggests in place of Exner's theory of optical inertia, that the stimulus of the greater attention-claiming quality will be apt to be considered first in point of time. With this view the writer of the present paper finds himself in full agreement.

TABLE II.

Subject.	Singles.				4		3		2		1		½		Av.	
	C.	F.	C.	F.	C.	F.	C.	F.	C.	F.	C.	F.	C.	F.	C.	F.
C	89	44	[138]	[150]			20	7	31	20	66	35	20	14	61	45
P	18	19			7	16	12	7	12	12	37	—	49	34	23	17
Wm	183	38			5	4	5	5							64	16
Ck	80	69	[35]	[20]	32	13	10	6	23	10	26	37	68	68	39	32
Sm											34	24	39	45	37	35
S	36	33	[41]	[35]					20	9	37	18	40	24	35	24
Average	81	41	[71]	[68]	15	11	12	6	21	13	40	29	43	37	43	28

The prominence of the flash in consciousness is further attested by the tendency, that nearly all the subjects noticed in themselves, to connect the click causally with the flash, which seemed to travel along the tube. If the click seemed at the end of the

tube where the flash appeared to originate, it was called first; if at the other end, the click seeming a result of the flash, like thunder after lightning, it was called last. Whether the attention-claiming powers depended on a greater intensity in the flash or a greater weakness, cannot now be said with certainty. The flash appeared to some to be a more intense stimulus to the eye than the click to the ear; to others the reverse was true. Most of the subjects felt unable to compare them. Meumann[1] found that a strong stimulus could catch the attention, and thus be placed earlier; Drew[2] that a faint stimulus had the same effect. Probably both tendencies are found under different conditions. It appears most probable that the weakness of the flash, or rather the necessity of attending to it, is the factor most effective in these experiments. The flash necessitates accommodation and a watching of the box; while the click seems to force its way into consciousness unaided. It would be interesting to repeat the experiments with a visual stimulus arranged to illuminate the whole visual field with a sudden glow, so that the elements of visual attention could be reduced to equality with the aural. Another point of interest is the fact also brought out in all of the experiments of Miss Hamlin and in most of Drew's work, that the external conditions of the experiment determine strongly the direction of the subject's attention, and that any attempt at voluntary attention defeats itself and reduces the number of correct answers.

It yet remains to speak of the effect of a series of stimuli as compared with single pairs, and of the various rates of succession of the pairs in the series. Inspection of Table II shows that the tendency to perceive the flash first is the same in all the rhythmical series as in the single pairs, and therefore that the difference of result between Exner and Gonnesiat on one hand, and Miss Hamlin and her supporters on the other, cannot be due, as she suggests, to this difference in method. It will be seen, further, that at all speeds a series of stimuli decreases the least observable interval, and that with the exception of a single subject in a single test, this time decreases directly as the length of time between the pairs of stimuli increases.

The subjects all testified that at the rates designated as 'four,' and usually at 'three,' no effect of rhythm was perceptible. S. had only occasional feeble rhythmic effect at 'two.' In these forms, the experiment is obviously reduced to ten chances of diagnosing the same single pair. For this reason the slow rates were not given to all the subjects. Under these

[1] Beiträge zur Psychologie des Zeitsinus, *Phil. Studien*, IX, 291 ff.
[2] Attention: Experimental and Critical, *American Journal of Psychology*, VII, 1895-'96, 539 ff.

circumstances, too, the extremely low intervals perceptible are not surprising. The usual method was to make a decision on the first pair, and then see if the others confirmed it. In the two-second series rhythm was generally noticeable and helpful; the one-second rate was most agreeable and pleasant; the half second very lively; the four-second "deathly slow" and "nervous." It should be mentioned that at the fastest rate the apparatus did not always function perfectly, occasionally skipping a click or flash. Subjective control and introspective analysis of method seemed also quite difficult at this rate, and here S. reported that the clicks and flashes failed to combine, but formed independent series.

To recapitulate briefly, this study has shown:

1. That the flash-click order can be recognized when the interval is shorter than that required for the click-flash order.
2. That this holds true for a series of pairs of stimuli as well as for a single pair.
3. That the serial repetition of the pairs materially reduces the time interval necessary for right judgment.
4. The cause of this seems to be a retardation of the click due to greater attention-claiming quality attaching to the flash.

XIII. The Time Required for Recognition.

By F. W. Colegrove.

The method employed in the following rough study was extremely simple. Sixty-eight pictures, three to four inches in length and two to three inches inches in height, were cut from an old magazine and pasted upon cards. These were inserted, one at a time, in the clips of the Cattell Fall-chronometer and exposed by the sudden falling of the screen. At the instant of exposure, the falling screen released one pendulum of an electrical vernier chronoscope, the other being released by the subject as soon as he was able to decide whether he had seen the picture before or not.[1] If the picture was recognized, the subject reacted with his right hand; if unrecognized, with his left. Five or six reactions to the letters R (right) and L (left) were taken before and after each sitting, and the discrimination times thus found furnish both a control of the other experiments and a means of finding the pure recognition time free of all peripheral processes.

[1] For the mode of operating the vernier chronoscope, see this *Journal*, Vol. IX, 191–7, Jan., 1898.